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PROFESSOR RONALD ROSS, C.B., F.R.S., *President*, in the Chair.

SOME DIPTEROUS INSECTS WHICH CAUSE MYIASIS IN MAN.

BY

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It is probably unnecessary to remind any Fellow of a Society which has the honour of having our distinguished President at its head, that the principal manner in which Diptera, or Two-Winged Flies, cause disease among human beings is by the inoculation, by certain blood-sucking species, of pathogenic micro-organisms, which enter the human body from the insect's proboscis when

the fly inflicts its bite. Fortunately for the human race, however, the blood-sucking habit is highly exceptional among Diptera, since the vast majority of species belonging to this ubiquitous Order of insects possess mouth-parts of a type which does not enable them to pierce the skin of a vertebrate. Yet, in addition to the *aggressive* disease-disseminators, as we may term the carriers of malaria, yellow-fever, dengue, *Phlebotomus*—or three-day fever, filariasis, and sleeping sickness, it is now recognised that under certain circumstances other Diptera play a considerable part in the dissemination of cholera and enteric fever, and possibly other diseases, such as summer diarrhœa in England and frambœsia or yaws in the West Indies. The insects concerned in these cases, which are chiefly the house-fly and certain allied species, are incapable of sucking blood, and may be designated *passive* disease carriers, since the specific disease-germs are mechanically conveyed by them, either on the exterior of their feet or bodies or in their dejecta, to food or drink, the lips of healthy individuals, or to lesions in the skin, as the case may be.

In both of the groups of diseases to which I have just alluded the insect, whether mosquito, sand-fly, tsetse or house-fly, is merely the vehicle, and does not itself cause the malady. There remains yet a third category of flies, chiefly belonging to the great Family Muscidæ, the larval stage of which is sometimes actually passed in the living human body, the presence of the larvæ in various organs and tissues, and the disorders or destruction of tissue caused thereby being comprehensively known as *Myiasis*. It is to certain of these flies that I wish to direct your attention to-night, and so far as possible I shall restrict myself to species which, in the course of my work at the

British Museum, have been submitted to me for determination by medical men and others in various parts of the Tropics. Since I have not the honour of belonging to the medical profession, it is perhaps unnecessary to remark that I am not concerned with remedies or methods of treatment, the subject of this paper being the insects themselves.

Myiasis is a phenomenon which affects not only human beings but also very many of the lower animals, including mammals, both domestic and wild, birds, fishes, and batrachians. While it would here be out of place for me to deal with any but human parasites, it may be of some interest to point out a fundamental difference which distinguishes the vast majority of cases of human Myiasis from most of the instances met with in other mammals. Generally speaking, although exceptions occur, when Dipterous larvæ are found in living mammals other than man they are those of Œstridæ (often known as "bots" or "warbles"), of which *Œstrus ovis*, Linn. (the nose bot-fly of the sheep), *Gastrophilus equi*, Clark (the bot-fly of the horse), and *Hypoderma lineatum*, Vill. (the common warble-fly of cattle in England), are familiar examples. Now these flies and many others belonging to the same Family which similarly infest wild mammals (chiefly ungulates and rodents), are in the larval stage *invariably parasitic* in the bodies of their hosts; they have no alternative mode of development, and a female bot- or warble-fly deprived of access to a mammal would be as incapable of perpetuating its species as a mosquito in the Sahara, a hundred miles from the nearest oasis or water-hole. While, as I hope to show later on, Œstrid larvæ occasionally infest man, such cases, although comparatively

often recorded, are nevertheless exceptional, most instances of Myiasis in the human subject being due to larvæ which are not habitual parasites, but are more usually found living and feeding in dead or decaying animal or vegetable matter, or in excrement.

As a rule Myiasis occurs either in the nasal passages and frontal sinuses, the external auditory meatus, the alimentary canal, or the subcutaneous tissue of one or other of the extremities, in the latter case the parent fly having in some instances deposited its eggs or larvæ in a wound or other lesion of the skin. The finding of maggots in the wounds of soldiers was a common experience of surgeons in the Crimean War, and there can be no doubt that the occurrence of Myiasis in the nasal fossæ and also in wounds and ulcers on the extremities is due to an aberration of instinct on the part of the parent fly, the insects having been lead astray by odours which, though repulsive to the human nostril, possess an overpowering attraction to certain flies. An analogous exhibition of perverted instinct has been observed in the case of *Calliphora vomitoria*, the country cousin of the familiar blow-fly or blue-bottle (*C. erythrocephala*), which has been known to oviposit on *Arum dracunculus*, being deceived by the corpse-like odour of the plant; while in Trinidad, B.W.I., it was found some years ago that the screw-worm fly (*Chrysomyia macellaria*) is attracted by the carrion-like odour of *Aristolochia gigas*, var. *sturtevanti*. Intestinal Myiasis, on the other hand, is probably caused in very many cases by the swallowing of the eggs or living larvæ in uncooked food, while occasionally, as in the case of intestinal Myiasis produced by the larvæ of species of *Sarcophaga*, which are viviparous, a pregnant living fly may have inadvertently

been swallowed. In this country, as also in America, intestinal Myiasis is perhaps most frequently produced by the peculiarly unpleasant-looking larvæ of *Homalomyia* (or as it now called *Fannia*) *canicularis*, a fly which is common in houses, somewhat resembles a diminutive house-fly, and consequently is sometimes ignorantly supposed to be a "young" specimen of its larger relative: in this case there seems reason to believe that the maggots make their way into the intestine through its terminal orifice. There remains a fifth kind of Myiasis, also often caused by the larvæ of the last mentioned fly and occasionally met with by medical practitioners in England, on the Continent, and in the United States. I refer to Myiasis of the urinary passages, but to this, although in some respects the most interesting of all, I now merely make passing reference, since in the present paper I wish to devote myself more especially to *Tropical* Myiasis, and as yet no cases of this particular form of the malady have been brought to my knowledge from the Tropics. Those who desire to learn more of this branch of the subject should refer to the elaborate paper published last year by Chevrel (René Chevrel: "Sur la Myase des Voies Urinaires;" *Archives de Parasitologie*, T.XII., No. 3, Febr. 10, 1909, pp. 369—450: figs. in text).

As I have already stated, the majority of flies causing Myiasis in man belong to the great Family Muscidæ, which, in its wider sense, is by far the largest of all the Families of Diptera, and includes not only the house-fly (*Musca domestica*, Linn.) and its near relations such as the blow-flies (*Calliphora*), green-bottles (*Lucilia*), the genus *Pycnosoma*, of Africa and the Oriental Region, and the screw-worm flies (*Chrysomyia*) of the New World,

but also the grey flesh-flies (*Sarcophaga*), the tsetse-flies (*Glossina*), *Stomoxys*, and an almost infinite number of species belonging to innumerable other genera. All of these flies, as their family name implies, exhibit a general resemblance to the house-fly in outward form and in the details of their external structure, and they breed, as a rule, in decaying organic matter or in excrement. While the majority lay eggs, the very numerous species of the universally distributed genus *Sarcophaga* produce living larvæ, and in any case (except in *Homalomyia*) the footless larvæ are whitish or yellowish grubs of the type commonly known as maggots. A Muscid maggot, which consists of twelve visible segments, is broader posteriorly and tapers to the cephalic extremity, from which the tips of the two powerful chitinous mouth-hooks, with which the creature rasps away its food, can usually be seen protuding. The main respiratory apertures, which are situate on the flattened or cup-shaped posterior surface of the terminal segment, consist of two groups of three slits, each group being surrounded by a chitinous plate, and there are two subordinate groups of apertures, or stigmata, on the first postcephalic segment. Larval life, in the Tropics at any rate, is usually short, generally lasting no longer than from four to six days, and at its conclusion the maggot contracts, and its skin hardens and darkens, assuming, as a rule, first a reddish and subsequently a reddish-brown hue, and forming a protective case or puparium within which the pupal or chrysalis stage is assumed. About a fortnight later the perfect fly makes its appearance, emerging through an aperture in the anterior end of the puparium, which the insect forms by forcing off a cap by means of pressure exerted by a dilatable vesicle in its

head. Under normal conditions the pupal stage of all Muscidæ is passed in the ground, so that, in a case of Myiasis, the larvæ, if allowed to remain undisturbed, would naturally leave their host on attaining maturity.

Apart from those caused by larvæ of Muscidæ and Œstridæ, the only cases of tropical Myiasis with which I am at present acquainted have been due to Phoridæ, a remarkable Family of extremely small flies, of a hunch-backed appearance, and usually dusky colour, characterised by a peculiar arrangement of the wing-veins and with very varied life histories, though many species normally breed in decaying vegetables. Two instances of Myiasis produced by a species belonging to this Family, in the one case in the eastern, the other in the western hemisphere, will be referred to later. In Europe, at any rate, intestinal Myiasis is occasionally caused by larvæ of species which one would certainly not expect to find in the human alimentary canal. Thus, during some four weeks in the autumn of 1907 a number of larvæ of the common drone-fly, *Eristalis tenax*, Linn. (Family Syrphidæ), were passed *per rectum* by a woman in Hampshire, who had recently arrived from France. These larvæ were forwarded for identification by Dr. H. McQuade, Eling Lodge, Totton, Hants, to Mr. S. G. Shattock, Royal College of Surgeons, by whom they were submitted to me. The larvæ of the drone-fly and allied species (commonly known as "rat-tailed maggots") are found in foul water, and since the patient in this case had, before leaving France, consumed a considerable quantity of watercress, the explanation of the presence of the larvæ in her intestine was not far to seek. Nasal and intestinal Myiasis due to larvæ of the cheese-maggot fly (*Piophila casei*, Linn.) are obviously capable of similar explanation; a number of such cases of

Myiasis occasioned by the larvæ of this particular fly are recorded in medical literature, and in November last flies and puparia of this species from larvæ passed from the human bowel were sent to me from Lisbon by Dr. COSTA-FERREIRA.

The literature of Myiasis is very extensive, dating back, as it does, for several hundred years, or, at least, to the time of Ambroise Paré, who, according to Mr. J. FOSTER PALMER, first described Myiasis of the urethra in in 1582: not to speak of the death of Herod, the king, who, as we know, was "eaten of worms" in A.D. 42. Those who are interested in the subject will find a most valuable summary in the "Bibliography" published eleven years ago by HUBER ["Bibliographie der klinischen Entomologie (Hexapoden, Acarinen)." By Med.-Rath. Dr. J. Ch. Huber, K Landgerichtsarzt zu Memmingen. Heft 3, Diptera. 8vo. Jena: Druck der Frommanschen Buchdruckerei (Hermann Pohle), Grossherzoglich Sächsische Hofbuchdruckerei. 1899. Pp. 25]. The greater number of cases recorded in this work, however, occurred in non-tropical countries; and although within the last few years many highly interesting notes and descriptions of tropical Myiasis have appeared in the medical journals, the student of tropical medicine will find it difficult to learn anything as to the names and characteristics of the Myiasis-producers most likely to be met with in the particular part of the globe in which his future lot may be cast. In the volume on "Tropical Diseases and Animal Parasites," in the last edition of ALLBUTT'S and ROLLESTON'S System of Medicine, less than a page and a half are devoted to the subject, and even within this short space there are several inaccuracies and misstatements. It is therefore not in any way

surprising that the contributors of notes on Myiasis sometimes err, when they attempt to assign generic and specific names to the parasites that they have observed. Under the circumstances, I may perhaps be forgiven if I venture to suggest that in such cases it is better not to apply definite names to genera and species, unless the designations have been duly verified, since the contrary course may lead to errors which eventually find their way into text-books.

Having said so much by way of introduction, I will now refer to a few of the principal genera and species of Diptera which cause Myiasis in different parts of the Tropics; and though, from the zoological standpoint, it would be more scientific to consider the genera and species concerned in proper systematic sequence, from a practical point of view it will probably be more convenient if I follow a geographical arrangement. I will, therefore, deal in turn with Africa, Asia, and Tropical America (including the West Indies). Up to the present, no cases of Myiasis have come to my knowledge from Tropical, or indeed any part of Australia.

AFRICA.

Cordylobia anthropophaga, Grünb.—This insect, which is very widely distributed in Africa, its range extending from Senegal to Natal, belongs to the same group of the Family Muscidæ as does the European blow-fly (*Calliphora erythrocephala*, Mg.), to which it is nearly allied. In appearance it is thick-set and compactly built; its general coloration is straw-yellow, with blackish markings on the dorsum of the thorax and abdomen, and its average length is about 9.5 mm. The full-grown larva is a fat yellowish-white maggot, 12 to 12.5 mm. (about

half an inch) in length, bluntly pointed at the anterior extremity, and truncate behind; its greatest breadth (on the sixth and seventh segments) is 5 mm. The body of the larva, from the third to the eleventh segment, is thickly covered with minute recurved spines of brownish chitin (darker in the case of larvæ ready to leave the host), usually arranged in transverse series of groups of two or more, which can be seen to form more or less distinct, undulating or irregular, transverse rows. In each of the two posterior stigmatic plates, the respiratory slit on either side of the median one is characteristically curved, resembling an inverted note of interrogation. The barrel-shaped puparium is on an average 10.3 mm. in length, by 4.6 mm. in breadth; its colour varies according to age from ferruginous to nearly black.

Cordylobia anthropophaga, which in Sierra Leone is known as the Tumbu- or Tumba-fly, forms a remarkable exception to the general rule that, exclusive of those belonging to the Œstridæ, the larvæ of Diptera that cause Myiasis in man are not normally parasitic, since, so far as is known at present, the larvæ of this insect are met with only in the tissues of a living host. Tumbu-fly larvæ are subcutaneous parasites in human beings (both Europeans and natives), monkeys, dogs, rats and probably other mammals. Each larva lives singly, forming a boil-like swelling in the skin, which always includes an aperture through which it breathes, the opening also forming a means of exit for the grub when the latter reaches maturity. While it frequently happens that only one maggot is found in an individual, the number is sometimes much greater, and Mr. G. A. K. Marshall records that in Salisbury, Southern Rhodesia, in 1901, no fewer than sixty of these maggots were extracted

from a single unfortunate baby. In Senegal, where the larva is known as the "Ver de Cayor," according to M. BÉRENGER-FÉRAUD dogs have suffered to an even greater extent, and the author in question tells us that on one occasion he counted *more than three hundred* larvæ in a single spaniel puppy; in this case it is not surprising to learn that the results were fatal! We do not yet know whether *Cordylobia* lays eggs or is viviparous, nor is it certain how the larvæ reach the parts of the body in which they are sometimes found. In any case, since (*pace* the author of the paragraphs on Myiasis in ALLBUTT & ROLLESTON) the ovipositor of the female fly is quite incapable of piercing the skin, the young larva must bore its own way through the integument by aid of its mouth-hooks.

It should be noted that within the last few years *Cordylobia anthropophaga* has been wrongly identified as *Bengalia depressa*, Walk., under which name it has frequently been referred to in literature; the true *B. depressa*, however, is a very different insect, the life-history of which is unknown, and there is no evidence whatever to show that its larva is a subcutaneous parasite.[1]

Sarcophaga.—As has already been remarked, the viviparous or rather larviparous genus *Sarcophaga* is very numerous in species and universally distributed. The members of this genus, which are flies of usually con-

1. *Cf.* E. E. AUSTEN, *Proceedings of the Entomological Society of London for the Year* 1907, p. xlvii. For a detailed description and figures of the larva and perfect insect of *Cordylobia anthropophaga*, *cf.* E. E. AUSTEN, "The Tumbu-Fly (*Cordylobia anthropophaga*, GRÜNBERG)": Journal of the Royal Army Medical Corps, 1908, pp. 5-11, Figs. 1 and 2. See also Major F. SMITH, D.S.O., R.A.M.C., "Tumbu-Fly Disease in Sierra Leone"; *ibid.*, pp. 1-2: and Major A. P. BLENKINSOP, R.A.M.C., "Observations on Tumbu-Fly Disease;" *ibid.*, pp. 3-4.

siderable or at any rate moderate size, are remarkably uniform in appearance, and resemble one another so closely that the species are exceedingly difficult to distinguish. Comparatively few of these species, in proportion to the total number in existence, have yet been described and named, and, since most of the recognisable distinctive characters are confined to the male sex, it is generally impossible to determine solitary females. In coloration the species of *Sarcophaga* are grey, with dark lines on the dorsum of the thorax, and characteristic, shimmering, chequered markings on the abdomen. Although these flies normally breed in carrion of all kinds, or in excrement, a large amount of Myiasis in man—chiefly nasal and cutaneous, but sometimes intestinal—is caused by their larvæ. A number of such cases have been recorded in Europe and the United States, though there is reason to believe that the majority of the European attacks are due to larvæ belonging to the closely allied genus *Wohlfahrtia*, in the perfect insects of which the light grey abdomen bears shining black spots, which do not change their shape and appearance according to the angle from which the fly is viewed. In South Russia, the large and handsome *Wohlfahrtia magnifica*, Schin. (syn. *Sarcophila wohlfahrti*, Portch.) is responsible every year for very many cases of cutaneous Myiasis in man and domestic animals, cattle, horses, pigs, sheep, dogs, and geese, besides human beings suffering from the attacks of the larvæ.

Sarcophaga (*species incerta*).—Although I am unable to record any actual cases of cutaneous Myiasis due to African species of *Sarcophaga*, the following instance of suspicious behaviour on the part of one of these flies is perhaps worthy of mention. At Zomba, in April,

1907, Sir ALFRED SHARPE, K.C.M.G., C.B., Governor and Commander-in-Chief of the Nyasaland Protectorate, crushed a female *Sarcophaga* inside his sleeve. The fly was forwarded to me by Major F. B. PEARCE, C.M.G., Deputy-Governor, with the following note, dated Zomba, April 12th, 1907 :—"On Sir ALFRED SHARPE shaking his arm the fly fell out. Some thirty small white maggots were issuing in every direction from the crushed fly's body, and it can only be presumed that the insect crept up Sir ALFRED'S sleeve for the purpose of depositing one or more of these maggots in (*i.e.*, on) his arm. They were very much alive as they came out of their mother's body." Dried specimens of the young larvæ, sent by Major PEARCE with the fly, are 1·5mm. in length, and under low magnification show dark transverse bands formed by minute spines. The fly itself is 11mm. in length, and, as in the vast majority of African species of *Sarcophaga*, its anal segments are orange- or ochraceous-rufous. Owing to the sex, not to speak of the sadly battered condition of the specimen, the species cannot be determined.

Writing in the *Journal of Tropical Medicine* for November 15th, 1905, p. 327, Dr. F. CREIGHTON WELLMAN stated that in Angola he had brought about experimental Myiasis in a goat by means of an undetermined species of *Sarcophaga*. "The animal," wrote Dr. WELLMAN, "was tied under a mosquito curtain in such manner that it could not move its head, and the flies liberated under the curtain. The larvæ were deposited in the nostrils, and produced erosions and necrosis."

Some four years ago, Mr. E. WARREN, of the Government Museum, Pietermaritzburg, forwarded to the British Museum (Natural History) an adult *Sarcophaga*,

which was stated to have been bred from a larva passed alive with "scores" of others from the intestine of a white girl in Natal. This fly, which is apparently nearly allied to *S. regularis*, Wied., although, being unfortunately a female, it is impossible to be certain as to its specific identity, is 11mm. in length, and, like the specimen killed by Sir ALFRED SHARPE, has the terminal segments of the abdomen ochraceous-rufous.

According to Dr. CREIGHTON WELLMAN, Myiasis, both intestinal and cutaneous, is not infrequent in Bihé, Angola, and this careful observer has described an intestinal case treated by him in that country, which was caused by larvæ of "*Anthomyia desjardensii*, Macq.," a species allied to *Homalomyia* (*cf.* F. Creighton Wellman, M.D., "Intestinal Myiasis in Angola," *The Journal of Tropical Medicine and Hygiene*, Vol. X., No. 11, June 1st., 1907, p. 186).

Œstris ovis, Linn.—In Algeria, according to Drs. EDMOND and ÉTIENNE SERGENT (Annales de l'Institut Pasteur, T. XXI., 1907, p. 392), the sheep bot-fly, *Œstrus ovis*, Linn., is responsible for a form of Myiasis among human beings, locally known as Thim'ni. The fly is said frequently to attack Kabyl shepherds, laying its eggs while flying in the eyes, nostrils and lips; the larvæ, when hatched, cause intense irritation of the conjunctiva, and of the cavities and sinuses of the nose and throat. Cases last about twelve days. The authors referred to consider that these attacks are probably due to the number of sheep being small, while the human population is fairly dense; cases are rare when sheep are numerous and human beings few and far between.

ASIA.

Aphiochæta ferruginea, Brun.—Passing now from Africa to the East, we will first consider a species which, though of extremely small size, is of remarkable interest, since there seems reason to believe that it is capable of passing through its entire life-cycle in the human colon. *Aphiochæta ferruginea*, Brun., which belongs to the Family Phoridæ, measures some 2 to 3 mm. in length, and is of an orange-ochraceous colour, with the dorsum of the thorax tawny, dark brown bands on the upper surface of the abdomen, and pale yellow legs, which, in the case of the hindmost pair have the femora tipped with brown. The British Museum possesses a very young pupa of this species which has apparently only just passed beyond the larval stage. This pupa is 3·5 mm. in length by 1·5 mm. in greatest width, buff-coloured (at least, after being preserved in spirit), and of the "boat" shape characteristic of pupæ belonging to this family, so that it looks like a small seed. It is convex above and below, and has a thickened rim running along each side. The anterior extremity, the upper surface of which is somewhat flattened, is at first tapering, then abruptly truncate; viewed from above, the posterior extremity is shaped like one end of an elliptical ovate figure, with a row of small spines round its edge. A little in front of the hinder margin, the posterior larval stigmata (respiratory apertures) can be seen in the form of two small brownish papillæ, situate close together; the prominent pupal breathing tubes, that will subsequently make their appearance near the anterior extremity, are not yet visible. Finally, it may be noted that an examination of this pupa shows that on the upper surface, the majority of the larval segments are each encircled by a single row of minute and rather widely separated spines.

It is evident that *Aphiochæta ferruginea* is very widely distributed in the Tropics, since the British Museum possesses examples of it from India, Burma, West Africa, and Central America; indeed, the species exhibits so remarkable an adaptability to varying conditions, that there can be little doubt that it has been introduced into fresh localities by human agency. Thus it may be mentioned that in February, 1892, *A. ferruginea* was found in London swarming in a box of live scorpions just arrived from Madras. The scorpions were packed in horse-dung, and some of the flies which were presented to the Museum were accompanied by the statement that the donor had seen the insect, or one looking exactly like it, swarming over decaying animal and vegetable matter in Madras. Typical examples of this fly recently received from India were bred, in the Indian Museum, Calcutta, from a decaying water-beetle (*Cybister limbatus*, Fabr.); and in Sierra Leone, in November, 1904, the species was obtained by Major F. SMITH, D.S.O., R.A.M.C., from larvæ feeding in putrid meat. At Belize, British Honduras, where, as I am informed by Dr. KARL HEUSNER, the species is plentiful round mangrove roots and displays a partiality for for decomposing shell-fish, Dr. HEUSNER bred it, in 1906, from larvæ, sixty-three in all, extracted by him from an Indian's foot.

In the *Proceedings of the Burma Branch of the British Medical Association* for 1891, pp. 11—16, will be found a paper by Surgeon-Major OSWALD BAKER, I.M.S., entitled "The passage from the human intestines of swarms of maggots and an explanation of the source from which they are derived." The maggots in question were passed *per anum* by a European at intervals during some ten months, and Surgeon-Major BAKER, who

attended the case, was satisfied that the trouble originally arose through the patient having consumed large quantities of candied bael fruit (*Ægle marmelos*, Correa), which on being examined was found to contain maggots of the same kind. Two of the flies bred from some of the maggots passed from the intestine were forwarded to me for identification, but it was only during the preparation of this paper that I have discovered the name of the species, a comparison with co-types received last month from Calcutta having proved beyond doubt that they are specimens of *Aphiochæta ferruginea*, Brun. By rearing the insects from the egg, Surgeon-Major BAKER found that when the larvæ were fed on human fæces, the entire life-cycle, from the hatching of one batch of eggs to the deposition of eggs by the resultant brood of flies, occupied 22 days. On the evidence adduced by Surgeon-Major BAKER, which can be consulted by those who are sufficiently interested, it appears to me that he is fairly justified in his conclusion (*op. cit.*, p. 15) that "these insects are capable of propagating, and do propagate their kind while sojourning within the human intestines." Since the consumption of the bael fruit, it is stated that the patient ate nothing which could have contained either eggs or larvæ, yet both *newly-hatched* and fully-grown maggots continued to be passed about every two months for nearly a year, while on one occasion, according to the patient's own statement (*op. cit.*, p. 28), "8 to 12 flies" were passed, "as well as a goodly number of maggots." In the same part of the "Proceedings of the Burma Branch of the British Medical Association" (pp. 28, 29), Surgeon-Major BAKER records the occurrence of larvæ of this fly in the intestines of two Karen girls, who were brought to the

General Hospital, Rangoon, suffering from what was considered to be Beri-Beri. It is obvious that it would be of much interest, and possibly of some importance, if the ability of *Aphiochæta ferruginea* to pass through its entire life-cycle in the human bowel were tested by properly controlled experiments on animals. May I, therefore, be permitted to express the hope that some of those present, who may be returning to the East, will take the hint, and subsequently communicate their results to the Society? It seems to me that there is nothing inherently impossible in Surgeon-Major BAKER'S conclusion, and, as showing the adaptability of Phoridæ to existence under abnormal conditions, it may be mentioned that species belonging to this Family are among the insects that have been found alive in corpses exhumed after being buried for two years. In one instance at La Fayette, Indiana, U.S.A., living larvæ, pupæ, and *imagines* (perfect flies) of a species believed to belong to *Conicera*—a genus nearly allied to *Aphiochæta*—were found in numbers in a corpse on exhumation after the period mentioned.

Sarcophaga (*species incerta*).—In a recent issue of *The Indian Medical Gazette* (Vol. XLIV., No. 10, Oct., 1909), Dr. R. LLOYD PATTERSON, late Medical Officer of the Empire of India and Ceylon Tea Co., Ltd., gave, under the title of "An Indian Screw-Worm," an illustrated account of a truly terrible and fatal case of nasal Myiasis in a coolie woman on the Borjuli Tea Estate, Tezpur, Assam. The victim was admitted to hospital suffering from various disorders on May 28th, and maggots were first removed (by douching) on June 6th, when 10 larvæ were brought away; on the following day "upwards of 50" larvæ were expelled, and 100 were removed on

June 8th, after which none were seen until June 12th, when 70 maggots were got rid of. On June 13th, the left orbital cavity was found "packed with hundreds of the maggots," and we are told that from June 16th to the 28th, when the patient's sufferings were mercifully terminated by death, from 50 to 70 larvæ were removed daily. It is, therefore, evident that during the course of the case there must have been constant re-invasion by fresh broods of maggots, and it is quite possible that these may have belonged to more than one species. Although Dr. PATTERSON does not state that he actually bred out flies from any of the larvæ removed by him, he speaks of "green-bottles" being associated with the case, and this designation and the description that he gives of the fly evidently refer to a species of *Pycnosoma*, a genus which, as I shall show directly, certainly causes nasal Myiasis in India. According to Dr. PATTERSON, in Assam the larvæ of "green-bottles" (*i.e.*, *Pycnosoma*) "are frequently present in the sores of cattle and more rarely in dogs and cats." The figures, however, of the maggot concerned in this case, which are given in the plate attached to Dr. PATTERSON'S article, show the larvæ of a species of *Sarcophaga*; and five larvæ from the case, which Dr. PATTERSON kindly sent me in response to my application for specimens, belong to the same genus. Dr. PATERSON describes the larva as "16 mm. long and 3 mm. broad at it widest part";[1] the maggots received by me, which are of different ages, are

1. The reader of Dr. PATTERSON'S description should note that the author mistakes the head of the larva for its posterior extremity, and that in speaking of "a powerful circular sucker" provided with certain organs, he is referring to the depression on the terminal segment and to the posterior stigmata contained therein.

somewhat smaller, measuring from 8·25 to 13 mm. in length.

Although no other instances of Myiasis in any part of the East due to species of *Sarcophaga* have as yet come to my knowledge, in India according to MONIEZ ("Traité de Parasitologie," p. 600), who quotes from RAILLIET, English medical men have reported very serious cutaneous Myiasis due to larvæ of *Sarcophaga ruficornis*, Fabr. The flies of this species, of which the British Museum (Natural History) possesses specimens from India and Siam, are generally about 12 mm. or half an inch in length and of a light grey colour, with the usual blackish markings not so dark as is often the case in this genus, while the antennæ and palpi are ochraceous-rufous, and the anal segments of the abdomen ferruginous.

Pycnosoma (*species incerta*).—The metallic blue, green, or purple flies belonging to the genus upon which BRAUER and von BERGENSTAMM bestowed the name *Pycnosoma* are the Oriental and Ethiopian representatives of *Chrysomyia*, a genus which is confined to the New World and includes the well-known Screw-Worm Fly (*Ch. macellaria*, Fabr.). In spite of the statement by the writer on Myiasis in ALLBUTT'S & ROLLESTON'S "System," the latter species does not occur in the Oriental Region, nor, indeed, anywhere outside America (North, South and Central), and the West Indies; and although the genus *Pycnosoma* is in the latest catalogue of Diptera ("Katalog der Paläarktischen Dipteren," Bd. III., by Dr. M. BEZZI and P. STEIN: Budapest, 1907, p. 543) regarded as synonymous with *Chrysomyia*, Rob.-Desv., there can be no doubt that it is really distinct. *Pycnosoma* can readily be distinguished from *Chrysomyia* by the absence of the three longitudinal dark stripes on the dorsum of

the thorax, characteristic of species belonging to the latter genus. Further distinctive characters are provided by the eyes in the male sex, and by certain bristles on the pleuræ or sides of the thorax. In the male the facets forming the upper two-thirds or three-fourths of the eyes are conspicuously enlarged in *Pycnosoma*, while in *Chrysomyia* the corresponding facets are, under an ordinary platyscopic hand-lens, not noticeably larger than those below; again, the sterno-pleural bristles are 1 : 1 in *Pycnosoma*, instead of 2 : 1, as in *Chrysomyia*.

I have not yet had an opportunity of studying the larvæ of any species of this genus, but an examination of puparia belonging to both Indian and African species of *Pycnosoma* shows that, instead of having thickened bands each bearing a number of closely set rows of minute spines, as in the larvæ of *Sarcophaga*, the body-segments in a *Pycnosoma*-maggot each bear a single more or less complete circlet of relatively large and widely separated spines.

The National Collection contains four specimens of an apparently new species of *Pycnosoma*, bred at Dehra Doon, U.P., India, in 1906, by Lieut.-Colonel F. Wyville Thomson, I.M.S., from larvæ from a case of nasal Myiasis in an old woman. When sending the flies to the Museum, in January, 1907, Colonel Wyville Thomson wrote: "The woman discharged about 100 larvæ from her nose, with great pain in the nasal region and frontal sinuses. The larvæ were all got out by injections, and the patient recovered. I bred out these flies by putting the larvæ in earth, into which they at once burrowed, formed brown chrysalises and hatched out in about 20 days, the weather being cold." The flies referred to are about 7 mm. in length, and have orange-

buff-coloured faces, chrome-yellow palpi and antennæ, and a hoary bloom on the front of the thorax. It may be added that the abdominal segments are devoid of the dark bands on their hind margins, characteristic of most if not all of the described species.

According to *The Medical Times & Gazette* for January 30th, 1875, nasal Myiasis is an ordinarily common malady in Rajputana, where it it known as "peenash"; references to literature will be found under this name in HUBER'S "Bibliographie."

TROPICAL AMERICA (including the WEST INDIES).

With the exception of *Aphiochtæa*, and of bot-fly larvæ of the genus *Dermatobia* (Family Œstridæ), the Myiasis-producers in Tropical America with which I am at present acquainted, all belong either to the genus *Sarcophaga* or to that known as *Chrysomyia*, the latter of which, as I have already explained, is closely related to *Pycnosoma*, its representative in Africa and Tropical Asia. So much has already been published concerning the notorious Screw-worm Fly (*Chrysomyia macellaria*, Fabr.), which is found from Argentina to Texas, that it need not detain us now; but a few words may be said as to another species of the same genus, *Chrysomyia viridula*, Rob.-Desv., which so far as I am aware has not hitherto been recognised as causing Myiasis in man.

Chrysomyia viridula, Rob.-Desv.—This species, which is considerably larger than *Chrysomyia macellaria*, was bred by Dr. DANIELS in March, 1899, in New Amsterdam, British Guiana, from a sore on a human being. It was also bred in Trinidad, B.W.I., in 1908, by Dr. S. M. LAURENCE,

from a larva discharged with between 100 and 150 other maggots from the nose of a woman suffering from facial Myiasis (*Cf.* S. M. LAURENCE, *British Medical Journal*, Jan. 9th, 1909, p. 88, and fig.). The specimen bred by Dr. DANIELS, which is a male, is 10·5 mm. in length, and similar to *Ch. macellaria* in coloration, having an ochraceous face and metallic bluish green body, with the dorsum of the thorax marked with the three broad, blackish, longitudinal stripes, characteristic of the genus *Chrysomyia*. Two puparia, which were sent by Dr. E. D. ROWLAND with this specimen, are 11 mm. in length by about 4·4 mm. in greatest width, dark seal-brown in colour, and still show the bands of coarse spines with which the larval segments were encircled. The anterior extremity exhibits three or four longitudinal wrinkles or puckers on each side, and at the opposite end the posterior larval stigmata, instead of, as in *Sarcophaga* pupæ, being situate in a pit, lie in a transverse groove. The fly bred by Dr. LAURENCE in Trinidad, and the remains of its puparium were figured by him in his article, where the insect is referred to as a "blue-bottle"; both specimens are now in the British Museum (Natural History).

Sarcophaga (*species incerta*). In *The Journal of Tropical Medicine and Hygiene*, Vol. XI., No. 20, Oct. 15th, 1908, p. 305, Dr. J. H. HARRISON published a description and illustration of a fatal case of facial Myiasis in a negro woman in British Honduras. According to the author:—"Altogether upwards of about 300 worms were removed," and "were found to be larvæ of *Lucilia maceliaria*, commonly known as the screw-worm." An examination of the larvæ, some 20 of which were presented by Dr. HARRISON to the British Museum (Natural History), shows however that they belong to *Sarcophaga*,

and not to *Chrysomyia*. The maggots are of different ages and sizes, and vary in length from 11 to 18 mm.; in every case the body-segments are surrounded by the circlets of minute spines, characteristic of larvæ belonging to the genus *Sarcophaga*.

Sarcophaga chrysostoma, Wied.—In 1899, Dr. E. D. ROWLAND, at that time Resident Surgeon of the Public Hospital, New Amsterdam, British Guiana (now Resident Surgeon of the Public Hospital, Georgetown, British Guiana), bred two species of *Sarcophaga* from larvæ which he removed, in the course of his hospital practice, from a sore on a girl's foot. The larvæ were extracted by Dr. ROWLAND on February 16th, 17th and 18th, 1899, and, in the case of one species, the flies emerged on March 2nd and subsequent days, while the perfect insects belonging to the other and much larger species began to make their appearance on March 8th. Dr. ROWLAND kindly presented a series of specimens and pupa-cases of both species to the British Museum (Natural History). The larger species, which I was able to identify as *Sarcophaga chrysostoma*, Wied., is one of the largest and most conspicuous of its genus, and eighty years ago was stated by its describer to occur in Brazil and the West Indies (*Cf.* Wiedemann, Aussereuropäische zweiflügelige Insekten, II., 1830, p. 356); it is, doubtless, widely distributed in Tropical South America, and I have met with it myself on the Lower Amazons.

This large and striking-looking fly, which is about 15 mm. ($\frac{7}{12}$ inch) in length, has a golden coloured face, three relatively broad and conspicuous black stripes on the back of the thorax, and ochraceous-buff anal segments. In the male the tibiæ of the hind legs and the distal halves of those of the middle legs are thickly

furred with long hair on the inner side. The empty puparium or pupa-case of this species, which measures some 13 mm. in length by about 6 mm. in breadth at its widest point, is dark reddish-brown (seal-brown) in colour, and, of course, of the usual barrel shape.

The second species which, so far I have not succeeded in identifying, is a very much smaller fly, being only about 7·5 mm. to 8 mm. in length, while its puparium is some 7 mm. long, and of a reddish chestnut colour.

It may be added that in Dominica, according to Dr. H. A. A. Nicholls, C.M.G., *Sarcophaga plinthopyga*, Wied., and other species of *Sarcophaga* which settle on sores are known as "Yaws-flies," since they are believed to be concerned in the dissemination of frambœsia or yaws.

When forwarding specimens in 1908, Dr. Nicholls wrote:—"These flies alight on sores, and in this way carry the contagium of yaws-disease from person to person. Since they will also settle on filth of all kinds and then on exposed articles of food, they are concerned in all probability with the spread of dysentery at times when it becomes epidemic, and they, doubtless, assist in the propagation of other germ diseases."

Dermatobia.—This genus of Œstridæ, which, in its larval stage, is normally a subcutaneous parasite of cattle and other mammals in Central and South America and the West Indies, sometimes attacks man in the same manner. It is seldom that an individual has more than one of these larvæ in his body at the same time, and I believe that the grub is generally found in the arm or leg, though occasionally the face may be attacked. In the stage in which the maggot is usually extracted, it is "tadpole"-shaped, having the anterior part of the body

swollen, and the posterior and longer portion so attenuated as to look like a long tail. The maggot in this stage may measure about 8 to 10 mm. in length, and is known in Cayenne as the "Ver macaque." Older larvæ are thicker, have a strongly wrinkled and warty appearance, and are much less attenuated posteriorly, though the hinder end is still the narrower of the two. In both stages the broader part of the body is surrounded by a series of circlets of large black hooks of chitin, which, being recurved, enable the creature to maintain its hold in its subcutaneous cyst. The National Collection contains five of these larvæ, all from different individuals. Four of the maggots were extracted in Eastern Peru, British Honduras, and Trinidad, B.W.I. The fifth larva, which was presented by Sir FRANCIS LAKING, Bart., G.C.V.O., and measures, after being preserved in spirit, some 9 mm. in length, was removed in London in 1897 by Mr. TREVES (now Sir FREDERICK TREVES, Bart, G.C.V.O., C.B.) from the side of the face of a patient who had returned from Central South America. Contrary to what we find in ordinary Muscidæ, the larval stage in Œstridæ, which, as was explained at the commencement of this paper, are always parasitic at this period of their existence, lasts for many months, and in this case it is believed that seven months had elapsed between the time when the egg was deposited and that at which the larva was removed.

Since the perfect insect has never been bred from any *Dermatobia* larva removed from the human subject, the precise species which troubles man in this way is still a matter of some little uncertainty. In all probability, however, the larvæ described above are those of *D. cyaniventris*, Macq., a stoutly-built fly measuring some 11·5 to 12·5 mm. in length, with an ochraceous-buff-

coloured face, prominent upper part of the head, dark grey thorax, metallic dark blue or purple abdomen, and brownish wings. *D. noxialis*, Goudot, if really distinct from *D. cyaniventris*, Macq., is a somewhat larger species.

Before concluding this paper, which, if it has done nothing else, may at least have served as a commentary on Tennyson's "infinite torment of flies," I should like to emphasise the fact that in many instances of Myiasis due to larvæ belonging to the genera *Sarcophaga* and *Pycnosoma*, the identity of the species causing the trouble is still a matter of uncertainty. Species can be determined only from the perfect insect, and if medical practitioners who have to treat cases of Myiasis would be at the pains of breeding out the flies from some of the larvæ removed by them, many gaps in our knowledge of this interesting though unpleasant subject would soon be filled. All that is necessary is to place the maggots on the top of a pot containing some fairly dry earth, and to cover the vessel with muslin. The flies, which will thus be caught on making their appearance, should be killed by exposure to chloroform or cyanide, but, since it is absolutely essential to give the integument, legs, and wings time to harden and to assume their natural colours, from 12 to 24 hours should be allowed to elapse before transferring the insects to the lethal chamber. For transmission to England they should be screwed up loosely in cigarette paper, and packed in a small metal box. The sexes can be distinguished by the eyes in the male being either actually in contact, or close together on the top of the head, while in the female the eyes are wider apart. Three or four examples of each sex are necessary, and they should be accompanied by their puparia, and by some of the larvæ and pupæ in

spirit. All such specimens addressed to me at the British Museum (Natural History), Cromwell Road, London, S.W., and accompanied by particulars, will be gratefully received, and duly examined and reported upon.

DISCUSSION.

Dr. C. W. DANIELS said that of course in the West Indies they recognised the study of Diptera as an important branch of Medicine, and one that should not be neglected. He had not seen any cases of Myiasis anywhere else except in British Guiana that attacked extensively the nasal or other passages. In British Guiana the larvæ of Dermatobia were found in the uncovered parts of the body, whilst in the African Tumbu-fly it was usually round the waist, or in covered parts of the body. It looked therefore as if the larvæ were deposited in rather a different way. One could actually breed from ulcers—whether dirty, sloughy and neglected ulcers or comparatively clean ulcers. From the former one could breed a great variety of flies, whilst from the latter few species of fly seemed to be produced.

Dr. F. M. SANDWITH said he would like to say a few words which might appeal to Mr. AUSTEN not so much from the entomological as from the military point of view. Mr. AUSTEN mentioned in the first part of his paper the experience of surgeons in the Crimea who found maggots in the wounds of soldiers. In August, 1877, in the Russo-Turkish war, he (Dr. SANDWITH) was at the Shipka Pass, where a large number of Turks were wounded. The official report gave the number of wounded passing through the ambulance tents within eight days as 10,000, and there were only two surgeons

capable of operating. A large number of the soldiers were shot through the head and died on the field, but many others wounded in the head or face while fighting behind entrenchments, came to them within two or three days with their wounds literally filled with maggots. The extraction of these maggots from the sinuses of the head and face was a most disgusting process, and they found the only effective method was to wash them out with carbolic (1 in 40) or with a strong solution of salt. To remove the maggots entirely, the wounds required to be well syringed morning and evening for two days. On one occasion during the campaign he discovered 200 men whose wounds had only once been dressed in the nine days since the battle; maggots and stench were banished in two days by the vigorous use of carbolic acid and Condy's fluid.

Dr. Oswald Baker thanked Mr. Austen for his interesting and instructive paper, and regretted that he had not sufficient entomological knowledge to discuss it. He could only say with reference to the case of Myiasis reported by him, to which Mr. Austen had alluded, that there was no doubt in his own mind that certain dipterous flies were capable of living and propagating their species within the human intestine. He ventured to think that no one who had before him the evidence that had been presented to him could come to any other conclusion. The alvine evacuations of his patient contained maggots of different generations, some almost microscopic, others mature, about $\frac{1}{8}$ of an inch long; while the patient himself asserted that he had passed living flies on several occasions; and these phenomena persisted for months, notwithstanding the use of a diet, consisting exclusively of milk and farinaceous substances.

ON THE NATURE AND ORIGIN OF CALABAR SWELLINGS.

[By Sir PATRICK MANSON, K.C.M.G., F.R.S.]

Medical men who have much to do with patients from West Africa, more particularly with patients from Southern Nigeria, The Cameroons, French Congo and the Congo Free State, must frequently have seen cases of the West African disease known as Calabar Swellings, and been puzzled about the nature and etiology of this peculiar condition.

In an individual, probably otherwise healthy, an œdematous non-inflammatory swelling many inches in diameter suddenly and without obvious cause appears on a limb, or on trunk, head or neck. In a few hours the swelling, without redness or pain or other sign of inflammation or at most with a bruised or tense feeling, attains its maximum development and then, during the next day or two and without further trouble, slowly subsides. It never suppurates. This is what is known as a Calabar Swelling, so called because such swellings are common in and near Calabar. In the same subject they recur at irregular intervals of weeks or months during many successive years, and even long after the patient has left Africa for good. At one time the swelling is in one place, at another time in another place; occasionally, in certain individuals, it appears to have a predilection for a particular locality, notably the hands and forearms; but any area on the surface of the body may be attacked. I have never seen nor heard of a mucous surface being involved, but I am not in a position to assert that such surfaces are exempt. This is

an important point, and one requiring further investigation; for although a fugitive œdema involving the surface of the body may be of little importance as affecting life, a similar œdema occurring about the fauces, the larynx or urethra would be a very serious matter indeed, and may be the explanation of some of those sudden deaths we hear of from time to time as occurring in West Africa. Although I have seen a good deal of mental distress resulting from their presence and frequent recurrence, ordinarily a Calabar Swelling is more curious than important,

The object of the present communication is to suggest an explanation of this curious and it may be important disease, and to request those who have the opportunity to repeat an observation recently made, which, so far as it goes, tends to support a hypothesis formulated and published some years ago.

Though there are still many points to be cleared up on the subject, I take it that nowadays it is generally believed that these Calabar Swellings are in some way brought about by *Filaria loa* or by its larval microfilaria. The frequency with which this parasite and these swellings are associated in the same individual, and the identity so far as known of their respective geographical ranges and topical distributions distinctly point to this conclusion. It is quite true that in many cases of Calabar Swellings neither *Filaria loa* nor microfilaria loa have been or can be demonstrated: but it is equally true, as has been pointed out by others as well as by myself, that in many instances microfilaria loa is present in profusion in the blood and yet no *Filaria loa* has been seen crossing the eye or recognized under the skin; and, conversely, that gravid *Filaria loa* are sometimes seen in the eye and yet

no microfilaria are to be found in the blood. Evidently the parasite may be and often is lying and moving about in the tissues without betraying its presence either by showing itself in the eye, or beneath the skin, or by the presence of its young in the general circulation. Similarly, in those cases of Calabar Swelling in which neither the loa nor its microfilariæ have been detected, the parasite must nevertheless be present in some part of the body. It is easy to understand how larvæ may be found in the blood and yet the parent worms remain concealed in the deeper tissues; but why the larvæ do not show themselves in the blood in every instance of loa infection is not so easily understood, nor can I explain it. I know however for a fact that gravid loas may show themselves from time to time, and yet careful and repeated blood examinations, made at presumably appropriate times, may be fruitless as regards detection of hæmatozoal larvæ. The absence of larvæ from the blood therefore is not a valid argument, as some have maintained, against the filarial origin of Calabar Swellings.

Filaria loa is a connective tissue nematode an inch and half to two inches or more in length, and about the thickness of a medium-sized sewing needle. The uterus of the mature female is packed with sharp-tailed and sheathed larvæ in every respect identical with the hæmatozoal larvæ of diurnal habit, formerly called Filaria diurna but now more appropriately designated microfilaria loa. The parent worms, as conclusively shown by Brumpt, Wurtz and Penel, may be present in large numbers. They wander about the body in the connective tissue, sometimes traversing the subconjunctiva and showing themselves there, sometimes travelling just under the skin of the trunk or limbs or

face, where, on approaching the surface, they cause a little itching, and where their presence may sometimes be recognised by a slight serpentine elevation distinctly visible as the underlying worm travels along in vermicular fashion at about the rate of half an inch a minute. Ordinarily, even when close under the skin, the parasites cause no marked swelling unless the part be scratched or irritated. How their larvæ contrive to enter the general circulation is not known; probably on being emitted into the connective tissue they find their way along the lymph spaces into the lymphatics and so into the blood.

That the adult worm does not usually give rise to much irritation or to pronounced swellings I am convinced, for months may elapse, the worms all the while moving about the body, and yet no Calabar Swelling appear. Some years ago I had a patient whose blood teemed with microfilaria loa, and who used to amuse himself by harpooning with a needle the adult loas as they wriggled their way under the skin on his chest or abdomen. He became quite an expert at this form of sport, and on three occasions sent me what I might term the fruits of his spear in the shape of fragments of mutilated loas which he had succeeded in impaling. Evidently this man was the host of a large number of these parasites, and yet, though the worms were numerous and active, it was only at long intervals that he had a Calabar Swelling. The mere presence and movements of the worms therefore do not cause the characteristic œdema.

Thinking about this matter it occurred to me that Calabar Swellings must be produced in one or other of four ways.

(*a*) By lymphatic obstruction. This I dismissed as untenable, seeing that the worm lies not in a lymphatic vessel, but, so to speak, free in the connective tissue.

(*b*) By some irritating glandular secretion emitted from time to time. This too I dismissed as I failed to understand the object, viewed from the standpoint of the interests of the parasite, of such a secretion.

(*c*) By fæcal discharges from the alimentary canal of the worm. This too I dismissed as unlikely, seeing that such discharges were probably of frequent occurrence, whereas Calabar Swellings are relatively infrequent; nor could I see any object in the interests of the parasite why nature should have endowed the fæces of the animal with irritating properties.

(*d*) Lastly, by periodical and normal emptying of the contents of the uterus of the gravid female worm into the connective tissue of the host.

This last was the hypothesis I favoured, because it appeared to me to conform with the interests of the parasite as well as to explain the phenomena of the disease. One can understand how a mildly irritating action, such as could be produced by the moving larvæ, would, by causing the effusion of a large quantity of serous fluid, assist the emitted larvæ to move along the now distended lymph spaces and be flushed into the lymphatic vessels and so finally into the general circulation. It is well known that if a Guinea worm, also a connective tissue parasite, be ruptured by indiscrete traction and her larvæ in vast numbers thus discharged into the connective tissue she lies in, almost immediately an œdematous swelling, comparable in a sense to a Calabar Swelling, results, provoked doubtless by the irritating properties of the larvæ or other contents of the

uterus of the ruptured worm. The analogy seems to favour my speculation.

For several years I have been on the outlook for an opportunity to test this hypothesis as to the nature and origin of Calabar Swellings. Some three or four years ago I attempted to prove it by examining the serous contents of one of these swellings, but as in that instance the swelling was of some standing and subsiding at the time, it did not afford me the best chance of success, and I failed to obtain the evidence I was in search of.

I have many times asked such patients to come to me for examination immediately on the first indications of the commencement of one of their Calabar Swellings, but it was only recently that I succeeded in getting a suitable opportunity. The patient in question had resided for several years in Southern Nigeria. His blood teemed with microfilaria loa and, in addition, it contained a few microfilaria perstans. For several years he had been troubled with Calabar Swellings. I told him to come to me at once should he be in London when one of the swellings commenced. One evening, about 8.30, early in January of this year he turned up at my house with a well-marked Calabar Swelling on the back of his left hand. He informed me that it began about one or two o'clock the same afternoon. The back of the hand was much swollen. His friends had told him it was the gout. He knew better; there was no pain. I got him to indicate precisely what he considered to be the starting point of the swelling, and he referred me to a spot between the metacarpal bones of the ring and middle fingers of the left hand, about an inch from the knuckles. On my pressing here with the tip of my finger he said it was slightly tender. I marked the spot

with a dot of ink, and entering a hypodermic needle about three quarters of an inch from the indicated spot, I pushed the needle through the œdematous tissues till the point lay under my mark or perhaps a little beyond. I then aspirated, endeavouring to withdraw some of the effused serum into the syringe. Nothing showing in the barrel of the syringe I detached this from the needle and then withdrawing the needle blew the contents of the latter on to a microscope slip. I obtained in this way a droplet of clear fluid which appeared to the naked eye quite untinged with blood. I repeated the operation and made a second preparation, in both instances spreading the small quantity of fluid over about half an inch square of the slip. After allowing the films to dry, I stained one with carbol-fuchsin, the other with logwood. There was very little blood; here and there only one or two red blood corpuscles. On the other hand there were many polymorphonuclear leucocytes, and in one slip thirteen and in the other slip seven microfilariæ possessing all the characters of microfilaria loa.

It must be conceded, I think, that these findings are strong evidence in favour of my hypothesis. I do not claim that they prove it. There are possible fallacies which cannot be ignored. For example, the patient's blood contained many microfilariæ at the time the swelling was explored, and it may be that some of these had escaped with the serum that was rapidly being effused into the connective tissue; or it may be that my needle tapped some capillary in which an unusual number of microfilariæ had accumulated. All I claim for the observation is that it supports my hypothesis, and, moreover, that it justifies a repetition of a similar investigation in suitable cases. Personally I may not have another

opportunity; but others are sure to have, and I trust they will take advantage of it and report the result.

There are one or two points which must be carefully attended to in carrying out such an investigation. In the first place the swelling must be quite recent, only of a few hours' standing, and on the increase; and, second, the exploration must be made as near as possible to the point of origin of the œdema; and, lastly, when aspiration is made the needle-point must lie in the œdematous tissue. Any preparation containing much blood should be rejected. I would prefer to explore Calabar Swellings in the case of patients in whose blood there are no microfilariæ to be found, for, if in such a case microfilariæ were obtained from the œdematous swelling, they could not be regarded as coming from accidentally aspirated blood, and my hypothesis will be proved to be correct. Any medical man, and I suppose there are such, who is himself the subject of Calabar Swellings, or who is in daily association with Calabar Swellings patients, could easily settle this interesting and perhaps important point in tropical pathology.

Discussion.

Dr. G. C. Low said he would like to make one or two remarks on Sir Patrick Manson's very interesting paper. Personally he (Dr. Low) agreed with Sir Patrick's idea that the Calabar Swellings were due to the *Filaria loa*, and he thought that the hypotheses put forward to explain their origin were distinctly ingenious, and in all probability correct. Of course, as regards the experiment of drawing fluid from the swelling, the results—as Sir Patrick himself admitted—were vitiated by the possible contamination of blood, the patient having numerous

filarial embryos in his peripheral blood at the time of puncture. To make such an experiment perfect, one would require to take a person with no embryos in the peripheral blood, and then puncture a Calabar Swelling, and demonstrate the embryos in the juice removed. He thought that any of the medical men practising in Calabar and that neighbourhood, could try such an experiment, practically at any time, and so settle the point. As regards the relationship of the diurnal embryos (F. diurna) found in the blood of people coming from Southern Nigeria and the neighbouring colonies, with the young or embryonic forms of the *Filaria loa*, and their difference from the young of Filaria bancrofti, he again entirely agreed with Sir PATRICK, and could adduce further points in favour of the correctness of these views. In text books and other places, it was generally stated that the young embryos expressed from the uterus of the adult female *Filaria loa* were identical with the diurnal forms found in the peripheral blood in the same districts, but that the latter were, to all intents and purposes, identical with the microfilaria bancrofti. The latter part of that statement he (Dr. LOW) wished to show was incorrect, as from a series of careful measurements he made some years ago, he came to the conclusion that the microfilaria loa (F. diurna) found in the peripheral blood presented different measurements to the embryos of Filaria bancrofti. The former measured from ·210 to ·280 of a millimetre in length (average measurement ·240 mm.), the latter (m.f. bancrofti) from ·290 to ·320 of a millimetre in length (average measurement ·310 to ·317 mm.), the v spot in the former being situated ·060 mm. from the head, in the latter ·090.mm. from the head. That clearly shewed that the two embryos were distinctly

different, and could not be the same. Further, the average measurement of 30 embryos expressed from the uterus of an adult *Filaria loa*, sent to him by Dr. CURRIE, of Lagos, gave a length of ·245 mm., an exactly similar figure to the so-called F. diurna. He believed, therefore, that the time had come for abolishing the name Filaria diurna and substituting in its place the term microfilaria loa. At the same time, however, he would sound a word of warning as to any filaria embryo seen in the blood by day being called a microfilaria loa. The embryos found in the Philippines and Fiji—embryos which appeared to occur as frequently in the blood by day as well as by night—might only be microfilaria bancrofti with an irregular periodicity, or they might even represent another species, but certainly they were not the microfilaria loa. He thought that the complete diurnal periodicity was a very strong point in the case of the diagnosis of microfilaria loa, the inability to change the periodicity of this filaria by inverting the habits of the patient—an experiment he had very carefully carried out on one of Sir PATRICK MANSON'S cases at the Seamen's Hospital—being another point which clearly separated the embryos from those of F. bancrofti, and was one—if its constancy was confirmed in other cases—which he (Dr. LOW) thought might be made use of in the future.

Dr. T. B. ADAM said he had seen one or two cases in which there were no swellings at all. One case suffered from Filaria for a period of 25 years, and he had had between 20 or 30 filariæ removed. When one was removed within a few days another would come, and then it might be a considerable time before he got more. The day after he stated that he never had a swelling, a small

swelling appeared on the back of his right hand, quite typical of Calabar swelling. As to the question of their being œdematous he thought it was only occasionally that they were so. Also as to the symptoms lasting only two or three days he thought it was not uncommon for them to last two or three weeks, and sometimes longer. He had made an attempt in one case to communicate Filaria from one subject to another by means of mosquitoes. He did not know enough about entomology to name the species, but the mosquitoes used belonged to the culicini, he had got them to feed on a patient who had had Filaria loa of the eye. About two years after the infection of the eye Filaria loa were found in the patient's blood, and at the time of the experiment were in his blood. About three weeks after they fed on the infected patient he got them to feed on a man who had no micro-Filaria loa in his blood, whom there had been no swellings and no Filaria in the eye. About a month later this man had his first swelling, and the loa has since appeared in the eye. It was unfortunate that he lived where a considerable number of natives were infected, as this vitiated the experiment. He hoped personally to afford an opportunity in the near future of repeating Sir PATRICK MANSON'S experiment, which would be more conclusive, as he had no micro filariæ.

Dr. R. LEIPER said he thought that the only crucial experiment that could set aside the theory would be the discovery of male sex in a worm that caused a Calabar swelling and not whether there were embryos in the blood. He did not regard this latter point one of importance; moreover, the experient took place at night. Sir PATRICK MANSON did not discuss the *cause* of the

sudden "swelling" of the embryos out of the worm under certain conditions, and the absence of these when the mature worm was present under the skin in other conditions. Were they normal? Might they not have something to do with the nipping or catching of the worm during its progress? He would like to know Sir PATRICK MANSON'S view as to the position of the adult Filaria in these Calabar swellings. When one recollected the anatomy of the worm, the presence of numerous minute bosses on the skin, its tapering from the thickened end gradually towards the posterior, one could easily understand that if it got into a difficult position or became caught between strands of fibrous tissue, it might then be unable to release itself easily, owing to its shape and its muscular efforts might induce an unpremeditated labour. This might be the cause of the swelling.

Professor RONALD ROSS said he would like to ask Sir PATRICK MANSON to let them have some estimate as to the number of embryos in the patient's blood; and also if he could tell them the number of embryos found in the small drop of serum taken from the swelling. That might help them in coming to some conclusion as to whether the embryos found in the serum had or had not come from an accidental admixture of blood.

Sir PATRICK MANSON in reply said that the patient had an enormous number of larval filariæ in his blood at the time of observation. He thought there were about 50 on the slide. which was about ¾-inch, and fairly thick. It was a heavily infected case. One speaker had mentioned the occurrence of Filariæ in pairs. It was a

remarkable thing; he had noticed before that these parasites did appear to travel through the tissues in pairs. Perhaps one loa would pass over the eye and it was by no means unusual that another loa followed, the suggestion being that the male hunted the female through the tissues or *vice versa*. The patient he referred to as an expert at impaling the loa, and who had sent him (Sir P. MANSON) two or three mutilated loa procured in this way, observed that they usually appeared one after another, as if following each other. As to the cause of the swelling suggested by Dr. LEIPER, that he was not qualified to discuss; it was quite possible, but whether it was so he could not tell. The loa had a predilection for particular parts of the body, especially the backs of the hands and forearms; it was strange that they should get nipped, especially there, and not in other situations. The whole subject of Filaria loa required much more study; it prevented many problems as yet unsolved.

The PRESIDENT thanked Sir PATRICK MANSON for his Paper and congratulated him on obtaining this evidence of a theory which he knew Sir PATRICK had held for fifteen years.

THE ETIOLOGY OF BERI-BERI,

BY

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AND

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The suggestion of a causal relationship between the consumption of white rice and the disease Beri-Beri was first formally made in this country by BRADDON[1]. This observer also drew attention to the important fact that those who consumed rice that had been parboiled before husking remained free from the disease, as did also the native Malays who consumed rice prepared by primitive methods of pounding and winnowing.

A series of observations made by the writers[2] in 1907 on two parties of labourers under conditions which excluded or adequately controlled the operation of factors other than diet, confirmed the correctness of this view of the causation of the disease. The prior observations of FLETCHER[3] and LUCY[4] in this country, and of DUBRUEL[5] in Indo-China, and the recently published observations of ELLIS,[6] furnish further testimony, and it may now be claimed that the theory rests on a solid basis of evidence.

The mechanism by which white rice was able to produce this result has remained in obscurity. BRADDON suggested that " the cause of this disorder is not indeed rice, *quâ* rice, or as an article of diet, but diseased rice; rice from which poison derived from decay, due perhaps

to some fungus, or mould, or germ, or spore, originally perhaps growing upon the husk has become mixed during the process of milling; or upon which such fungus may have grown and such poison have been produced after decortication." EIJKMAN,[7] from experiments on fowls, concluded that a definite poison exists commonly in rice, and that for this poison or its effects something or substances in the pericarp was an antidote. DUBRUEL conceived the ingestion of an organism associated with white rice, which organism multiplying in the body produced the disease.

Following the line of thought suggested by the poison hypothesis researches were undertaken to determine whether from white rices actually associated with outbreaks of beri-beri there could be extracted by means of various solvents any substance or substances recognisable by chemical or biological methods as poisonous in character. These researches failed of their object, though it is admitted that the accuracy of the poison hypothesis was not thereby disproved.

Certain results which emerged from chemical analysis and histological examination of the rices turned attention to the possibility of an explanation of the course of events on an hypothesis of a defect of nutrition. That this explanation was inadequate, if dietary constituents as estimated by the ordinary analytical methods were alone considered, had been shown in the preliminary investigation.

By a series of experiments on domestic fowls the details of which will be supplied in a later publication, it was shown that these animals when fed on various kinds of rice were sensitive to differences between them. By further and repeated experiments with

rices known to have been associated with outbreaks of beri-beri, and with controls under identical conditions fed on parboiled rice, it was established that a certain reaction in fowls might be taken as an indicator of the beri-beri producing power of a given rice when forming the staple of the diet in man. Whether the disease produced in fowls be accepted or not as analagous to beri-beri in man, the validity of the arguments here advanced remains unimpaired. Rices were available that were known to have been associated with outbreaks of beri-beri; samples had been taken daily during the continuance of the preliminary inquiry in 1907, and through the courtesy of Dr. J. D. GIMLETTE and Dr. G. D. FREER we were enabled to procure white rice which was being consumed prior to an outbreak of beri-beri among Malays at the Kuala Lumpur Police Depot, which outbreak ceased on changing the rice supplied to the parboiled variety. It was shown that these rices when fed to fowls constantly produced a certain disease in a large portion of them, while parboiled rice as constantly failed to produce this result in groups under identical conditions. It is our belief that this disease, Polyneuritis gallinarum is truly analagous to beri-beri in man, similar in its etiology, in its clinical manifestations and in its pathological effects, and that its occurrence should be held as important confirmatory testimony of the connexion between white rice and beri-beri. It is desirable, however, to emphasise the point that the acceptance or non-acceptance of this opinion is immaterial to the argument; for this purpose the occurence of the disease is employed only as a reaction. The fact that certain white rices when forming the staple of a diet in man produce beri-beri rests

on quite other testimony than that supplied by experiments on domestic fowls.

The commercial varieties of white rice are numerous, but in this country, apart from the grading as to quality, two varieties are in common use, and are known respectively as Siam and Rangoon.

From epidemiological considerations and from experimental evidence it appears that Siam rice is considerably more potent in its beri-beri producing powers than Rangoon rice.

The proteins, fats, carbohydrates, and ash were determined for the different varieties of rice which had been employed in the experiments, with the following percentage results calculated on dried material:—

	Protein.	Fat.	Carbohydrate.	Ash.
White rice (Siam) ...	9·07	0·17	90·11	0·65
White rice (Rangoon)	8·44	0·81	89·90	0·85
Parboiled rice ...	9·48	0·51	89·12	0·89

A comparison of these results shows that the only marked difference among the rices was in respect of fat, which was most abundant in the variety known as Rangoon, less abundant in parboiled rice, and still less abundant in Siam rice. These observations, taken in conjunction with the experimental results in fowls, excluded the possibility of an explanation of the origin of beri-beri on the ground of a deficiency in fat. It will be noted that these analyses did not include an estimation of the relative proportions of the inorganic salts composing the ash, nor did they take account of the manner of combination, organic or inorganic, in which these substances originally existed in the rice grain.

By a method devised in this laboratory, sections of the various rice grains were obtained of sufficient

thinness to permit the examination in detail of their histological characters. By suitable staining methods it was shown that in parboiled rice remnants of the pericarp remained attached to the rice grain, whereas in Siam rice the pericarp and the layers subjacent to it had been polished away. It would appear that parboiling renders the grain tough and non-friable, in consequence the peripheral layers cannot be removed so readily as in the untreated grain. It was further demonstrated that the layers so retained in parboiled rice contained the most of the aleurone and oily material present in rice grains. The reason for the difference between these rices in respect at least of fat was thus clearly demonstrated. Rice as prepared by primitive methods (Malay rice) was similarly examined, and, as might have been expected from the pounding to which this rice had been subjected, parts of the pericarp and subjacent layers were chipped off to a varying extent, but on the whole these layers were retained to a greater extent than is the case with white rice.

Early in the course of the experiments the observation was made that parboiled rice, subjected to exhaustion with hot alcohol and thereafter carefully dried in the sun to free it from alcohol, produced when fed to fowls a disease indistinguishable from that observed in fowls fed on white rice, though such parboiled rice in its original state was incapable of producing this result however long continued.

The association of the observations referred to in the two preceding paragraphs seemed to point a way to a solution of the problem. It had been shown that white rice as prepared in the mills of this country produced the same results in fowls as white rice known to have

been associated with beri-beri. If now a substance or substances residing in the outer layers which are milled away in white rice and are retained in parboiled rice could be added to white rice, and so prevent its harmful effects, it was conceived that the nutritive hypothesis would thereby be supported.

In accordance with this idea the following experiments were initiated: A rice mill in Singapore was visited, and there was obtained (*a*) a quantity of the original padi then being milled—in this case a partially husked padi imported from Indo-China; (*b*) a quantity of the finished product as it came from the machine; (*c*) a quantity of "polishings" from the same rice. Polishings, it may be stated, consist of the outer layers of the seed removed in the process of making the rice white. The miller estimates that 40 parts of padi produce 25 parts of white rice, 5 parts of polishings and 10 parts of husk. The polishings are sold as food for cattle, and the husks are burned as fuel in the mill.

Experiment A.—Twelve fowls were fed on the padi for five weeks.

Result.—All remained healthy.

Experiment B.—Twelve fowls were fed on the white rice alone.

Result.—In five weeks six had developed polyneuritis; two were dead, one having suffered from polyneuritis and one from a disease other than polyneuritis; five fowls remained healthy.

Experiment C.—Twelve fowls were fed on rice taken daily from the same bag as that used in Experiment B. In addition polishings in the form of emulsion, in amount equal to that milled from the quantity of rice consumed,

was fed by a tube passed into the crop daily. This quantity was subsequently diminished week by week, until only three grammes per kilogramme of body weight was being given daily, which amount sufficed to maintain the fowls in health and in constant weight.

Result.—The experiment was continued for seven weeks, and all remained healthy.

This result was subsequently confirmed for rice from known outbreaks of beri-beri.

It will be understood that these three experiments were in progress simultaneously, and that the fowls were in all respects under identical conditions.

Experiment D.—Part of the original padi was taken and milled by a Malay woman by primitive methods into the finished product as eaten by Malays. Eight fowls fed for five weeks on the rice prepared from the original padi by the Malay method, all remained healthy. Eight fowls only were used for this experiment, as the quantity of padi then remaining sufficed only for this number for the time it was estimated the experiment would last.

Attention is drawn to the important point that the products used in these experiments were all derived from the same lot of padi, and the results force us to the conclusion that it is the milling process which is essentially at fault; the polishing of white rice removes from the seed some substance or substances essential to the maintenance of the normal nutrition of nerve tissues.

To elucidate the point as to whether rice when freshly milled is less harmful than that which has become stale, an assistant was stationed in Singapore, who sent daily to the laboratory by the most expeditious route a quantity of rice milled on the day of despatch. Twelve fowls were fed on this rice and five developed polyneuritis in four

weeks. This result, which is similar to that obtained in other experiments when fowls were fed on rices milled from four weeks to two years, previously disposes of the suggestion that the harmfulness of white rice is due to its staleness or to the development in it of a poisonous substance or substances subsequently to its being milled. The root of the evil lies in the milling process itself. The result further indicates the inadequacy of preventive measures founded on the poison hypothesis in regard to the use of freshly milled rice.

An experiment was now planned to determine whether a parboiled rice, proved harmless, could by exhaustion with hot alcohol be reduced to such a condition that it would produce polyneuritis when fed to fowls, and whether the substance so extracted when fed to fowls with a white rice proved harmful, could prevent the development of polyneuritis. For this purpose parboiled rice was repeatedly exhausted with hot alcohol. The alcoholic extracts were concentrated in vacuo at a temperature of 52° C., freed from alcohol, and the residue emulsified in distilled water. Experiments with these products showed that fowls fed on the exhausted parboiled rice contracted polyneuritis, and that fowls fed on a white rice proved harmful by previous experiment remained healthy if they received in addition a quantity of emulsion.

Having by these and other experiments, the details of which are omitted, so as not to encumber the argument, arrived at the point when it was clear that the essential cause of beri-beri was to be sought for in a nutritive defect, further efforts were made to determine by chemical methods precise differences between various rices. Such differences, if they are to furnish an adequate explanation for the origin of beri-beri must be in accordance with

clinical observations and the experimental results in fowls.

Acting on a suggestion made to one of us by Dr. F. W. Mott, F.R.S., an attempt was made to estimate the lipoids of the different rices, but as the time element enters so largely into these estimations, and our experiments with fowls were proceeding rapidly, it was decided to determine the amount of phosphorus calculated as phosphorus pentoxide in the various rices in use. It speedily became apparent from these analyses that the phosphorus content of the different rices varied with their known harmful influence, the less phosphorus contained in a given rice the more liable was it to produce polyneuritis gallinarum in fowls, conversely the higher the phosphorus content the less likely was it to produce polyneuritis,

Thus a sample of parboiled rice, which was fed to fowls over many weeks, all remaining healthy, was found to contain ·469 per cent. P_2O_5, and a sample of white rice which produced polyneuritis in fowls yielded ·277 per cent. P_2O_5. The rice polishings employed in Experiment C. yielded 4·2 per cent. P_2O_5.

From a series of observations it was determined that a fowl under the conditions of our experiments weighing from say 1,200 to 1,400 grammes required 60 grammes of parboiled rice daily to maintain its health and nutritive equilibrium. In Experiment C. it was determined experimentally, the chemical analysis being then unknown, that when fed on white rice a fowl of this weight required the addition of about 3·5 grammes of polishings to preserve it in nutritive equilibrium. From the data given above it may be readily calculated what amount of polishings added to white rice is required to

raise the phosphorus content of the white rice diet to that of the parboiled rice diet. Thus—

60 grammes of parboiled rice ·3120 grammes P_2O_5.
60 „ white „ ·1662 „

Difference ... ·1458 „ P_2O_5.

Polishings contain 4·2 per cent. phosphorus pentoxide. Calculated from the phosphorus content therefore 3·474 grammes of polishings added to the 60 grammes of white rice supplied to a fowl of 1,200 to 1,400 grammes weight will preserve it in nutritive equilibrium. From experimental observation 3·5 grammes of polishings had been shown to accomplish this result.

There is thus afforded curious striking testimony to the value of phosphorus estimation as an indicator of the likelihood of a given rice to produce polyneuritis when fed to fowls, or following the argument the likelihood of its producing beri-beri when forming the staple in the diet of man.

We are greatly indebted to Mr. B. J. Eaton, chemist in this Institute, for valuable assistance in the chemical part of this investigation.

Dr. H. Schaumann has had the goodness to send us recently a copy of his address before the German Society of Tropical Medicine in which he stated his conjecture (Vermutung) that beri-beri was a disease of metabolism associated with a diet deficient in organically combined phosphorus.

SUMMARY.

1. Beri-beri is a disorder of nutrition, and as it occurs in this country is associated with a diet in which white rice is the principal constituent.

2. White rice, as produced in the mills here, commonly makes default in respect of some substance or

substances essential for the maintenance of the normal nutrition of nervous tissues. These substances exist in adequate amount in the original grain, and in superabundant amount in the polishings from white rice.

3. The estimation in terms of phosphorus pentoxide of the total phosphorus present in a given rice may be used as an indicator of the beri-beri producing power of such rice when forming the staple of a diet in man.

4. The prevention of beri-beri in this country will be achieved by substituting for the ordinary white rice a rice in which the polishing process has been omitted or carried out to a minimal extent, or by the addition to a white rice diet of articles rich in those substances in which such white rice now makes default. One such article, which is cheap and may readily be obtained, is the polishings from white rice.

The use of parboiled rice, as suggested by Dr. BRADDON, will achieve a like result, provided that the polishing process is not carried beyond the limited extent now customary.

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ELECTION OF MEMBERS.

The following were duly elected as Fellows of the Society :—

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